Fish and Shellfish Hygiene

Report of a WHO Expert Committee
convened in cooperation with FAO

Technical Report Series 550

World Health Organization, Geneva 1974

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Geneva, 18–24 September 1973

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FISH AND SHELLFISH HYGIENE

Report of a WHO Expert Committee convened in cooperation with FAO

A WHO Expert Committee on Fish and Shellfish [1] Hygiene, convened in cooperation with FAO, met in Geneva from 18 to 24 September 1973. The meeting was opened by Dr L. Bernard, Assistant Director-General of WHO, on behalf of the Director-General. He stressed the increasing importance of the subject and the need for public health workers to recognize its significance.

INTRODUCTION

In the field of food hygiene WHO and FAO are concerned with the prevention of the transmission of human disease through contaminated fish and shellfish and with improvement of the hygienic production, processing, and distribution of these foods. An important development relevant to fish and shellfish hygiene is the establishment of the Joint FAO/WHO Food Standards Programme, whose main responsibility is to prepare the *Codex Alimentarius*, a collection of internationally adopted standards for food and food products of importance to international trade, including fish and fishery products. The objectives of the Codex are to protect human health and to ensure fair practices in the food trade. Hygienic aspects of this work have been delegated to the FAO/WHO Codex Committee on Food Hygiene. Standardization of the quality of fish, shellfish, and their products is the main task of the FAO/WHO Codex Committee on Fish and Fishery Products. The Committee noted that earlier Expert Committees [2] had dealt with food-borne disease but only with certain diseases carried by fish and shellfish. However, with the increasing use of the

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[1] The term shellfish is taken to include a wide range of aquatic animals all characterized by the possession of a hard shell. The Mollusca include the bivalves that have two valves or shells (clams, cockles, mussels, oysters, etc.), the gastropods that have one valve (whelks, winkles, limpets, abalone, etc.) and the cephalopods that are without an external valve (the octapods and squids). The Crustacea are arthopods, most of which are mobile (crabs, lobsters, shrimps, prawns, etc.), although some have adopted the sessile habit (barnacles).

[2] Third Report of the Joint FAO/WHO Expert Committee on Zoonoses, *Wld Hlth Org. techn. Rep. Ser.*, 1967, No. 378; Report of a WHO Expert Committee with the participation of FAO on Microbiological Aspects of Food Hygiene, *Wld Hlth Org. techn. Rep. Ser.*, 1968, No. 399; Report on the European Technical Conference on Food-borne Infections and Intoxications, *Wld Hlth Org. techn. Rep. Ser.*, 1959, No. 184.

world's fishery resources and the increasing occurrence of newly recognized diseases in fish and shellfish, it is timely that an Expert Committee has been set up to deal specifically with public health aspects of fish and shellfish hygiene.

The total world catch of aquatic animals and plants in 1972[1] amounted to 65 600 000 tons, of which about 90% (59 400 000 tons) was fish of marine and freshwater origin and about 8% (5 200 000 tons) shellfish (molluscs and crustaceans), the remainder consisting of aquatic plants, miscellaneous aquatic animals, whales, seals, etc. Thus, large quantities of fish and shellfish are eaten and are an important constituent of the diet in many parts of the world. With the increasing shortage of protein, fish will assume greater importance as a food within the constraints of the capacity of the world's natural and cultured resources of fish and shellfish. Fish is a nutritious and relatively safe protein food but the extensive utilization of fish as food raises public health problems that will increase as new resources are exploited. Fish and shellfish are capable of transmitting many of the established food-borne microbial infections and intoxications. In addition, there are certain diseases that are most commonly associated with fish, shellfish, and the aquatic environment. Diseases of current concern in this connexion include organic mercury poisoning (Minamata disease), biointoxications, *Vibrio parahaemolyticus* infection, parasitic diseases, and botulism.

Further problems arise because of the perishable nature of fish and shellfish and any discussion of hygiene cannot ignore the effect of handling techniques on human pathogens, as well as on spoilage organisms. In addition, further public health problems may arise as a result of aquatic pollution.

It was recognized by the Expert Committee that the scope of the subject is so diverse and broad that not all the important factors could be dealt with in detail. The Committee therefore reviewed the principal human diseases associated with fish and shellfish and current public health problems related to the production, processing, and distribution of fish and shellfish that serve as food for man. Diseases caused by living organisms were dealt with in greater detail than those arising from biotoxins and chemical pollutants. The effects of local and general environmental factors were briefly considered, as well as other subjects relating to the scientific and administrative aspects of the problem.

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[1] *FAO yearbook of fishery statistics*, vol. 34: *Catches and landings*, 1972, Rome.

1. ENVIRONMENTAL FACTORS IN RELATION TO FISH AND SHELLFISH HYGIENE

Many environmental factors must be considered in relation to fish and shellfish hygiene and to prevention of disease arising from the consumption of fish. The environmental factors include those associated with the catching, handling, processing, and storage of fish and shellfish, those that are natural to the aquatic environment, and those resulting from man-induced changes in the environment leading to the presence of undesirable substances in fish and shellfish. Any control measures introduced to deal with such matters should, where possible, be directed at the origin of the environmental disturbance and the environmental control measures should be selected accordingly.

Control of the local environment involves consideration of food-borne diseases of microbial origin for which there exist well-known practices of cleanliness and management. These measures are equally applicable to quality control in fish and shellfish and include the maintenance of high standards of hygiene and the proper use of heat processing, cold storage, and other production and processing controls that have wide applicability to all foods.

Other environmental measures involve specific biological and ecological factors related to the aquatic environment. The relaying of molluscan shellfish in clean areas is an example of such an environmental control measure. Another example is the control of fish-borne parasites, which requires a thorough knowledge of biological cycles and relevant ecological factors.

At a different level are those problems created by man-made changes in the environment that may result in substances derived from sources of environmental pollution accumulating in fish and shellfish. These environmental contaminants may range from microorganisms present in sewage to heavy metals and other hazardous substances derived from industrial sources.

Problems arising from the catching and handling of fish and shellfish and the biological problems related to safe production of fish and shellfish will be dealt with in later sections. However, because of the breadth and diversity of subject matter related to the wider environmental problems, the Committee limited its consideration to the salient features of environmental control strategies rather than details of environmental control.

The relationship between the environment and the hygienic quality of fish and shellfish eaten by man are the concern of public health agencies at all levels, and the strategies to be adopted to improve quality will vary accordingly. Public health agencies should consider the following strategy,

among others, to deal with public health aspects of environmental pollution :

(1) Public health agencies in cooperation with food scientists, epidemiologists, etc., should identify substances present in fish and shellfish that are a potential risk to man,[1] or that reduce the acceptability of the product. This information must be sought from many sources, for such problems are multidisciplinary and public health agencies will need to call on scientists from many different fields to enable them to make an accurate appraisal of the problem.

(2) Public health agencies should then determine whether or not such problems relate to the fish and shellfish resources with which they are concerned. This usually requires local investigations which should include :

(*a*) Monitoring of foodstuffs, including fish and shellfish, at the consumer level for the presence of potentially hazardous substances.

(*b*) Monitoring the population to determine the pattern of food consumption, including that of fish and shellfish, to determine the magnitude and route of uptake of hazardous substances.

(*c*) Monitoring selected components of the population at risk to determine clinical or subclinical effects caused by hazardous substances in food, including those derived from fish and shellfish.

(*d*) Monitoring the environment to determine the distribution of hazardous substances and their likely source.

(*e*) Additional specific scientific and epidemiological investigations that might be indicated from information obtained through monitoring.

These investigations embrace a wide range of disciplines, and the way in which the investigations should be directed and coordinated is a matter to be decided locally, but it is essential to maintain close cooperation between the various agencies and their scientists. With regard to fish and shellfish quality and environmental monitoring, it may be necessary for investigations to be undertaken at a regional level. In such circumstances,

[1] The UN Conference on the Human Environment held in 1972 recommended that FAO and WHO jointly establish a programme of research and monitoring of food contamination by chemical and biological agents. It was recommended that the results of this monitoring should be assembled, evaluated and made available so as to provide early information on trends and on levels that may be considered undesirable or may lead to unacceptable human intakes. During consultations between WHO and FAO, it has been suggested that the following agents should be monitored in shellfish : cadmium, viruses, paralytic shellfish poison, *Vibrio parahaemolyticus*. In addition, cobalt, mercury, and phthalate esters should be monitored in fish.

See also : Ruivo, M., ed. (1972) *Marine pollution and sea life*, London, Fishing News (Books) Ltd.

coordination should then be the responsibility of the accepted regional body competent to deal with the problem.[1] In order to allow the wider implications of such studies to be considered the results of national and regional monitoring schemes should be made available to those agencies concerned with global monitoring.[2]

(3) From these activities, public health agencies should then be able to assess whether or not the consumption of fish and shellfish from a particular source presents an unacceptable risk to the consumer. The assessment of risk to the consumer as a result of accumulated hazardous substances in food and the relative role of fish and shellfish is complex. Some guidance in this can, however, be obtained from specialist publications.[3] Such assessments are particularly difficult for fish and shellfish as many substances, particularly heavy metals occur naturally in the marine environment, and some species naturally accumulate these substances. Where control measures are necessary, these can often be taken only after full discussions with other bodies, for the cost of preventing environmental pollution or of other steps to remove or reduce the risk to the consumer must be added to the social and economic costs that result from any action taken. Action that a public health agency may take, or may recommend to other bodies for them to consider, include :

(*a*) The prevention of contamination of the fish or shellfish by removal or reduction of the polluting source (i.e., cessation of the polluting discharge or treatment of the discharge).

(*b*) Treatment of the product to make it safer for human consumption (e.g., purification of shellfish to remove faecal pathogens).

(*c*) Restrictions on exploitation of fish and shellfish resources from specified areas (e.g., in areas polluted by metallic wastes).

(*d*) Restriction on rate of intake of contaminated fish and shellfish by the general public or selected groups of the public (in relation to cadmium, lead, and mercury in fish).[4]

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[1] Regional agencies concerned with environmental monitoring include the International Council for the Exploration of the Sea (ICES) in the north-east Atlantic; Conseil international pour l'Exploration de la mer Méditerranée (CIEMM) in the Mediterranean; and Indo-Pacific Fisheries Council (IPFC) in South-East Asia.

[2] International bodies concerned with global monitoring include the World Health Organization; Food and Agriculture Organization of the United Nations; Intergovernmental Oceanographic Commission; International Organization for Standardization.

[3] *Wld Hlth Org. techn. Rep. Ser.*, 1972, No. 505.

[4] Sixteenth Report of the Joint FAO/WHO Expert Committee on Food Additives, *Wld Hlth Org. techn. Rep. Ser.*, 1972, No. 505; *FAO Nutrition Meetings Report Series*, 1972, No. 51. Evaluation of mercury, lead, cadmium and the food additives amaranth, diethylpyrocarbonate, and octyl gallate, *WHO Food Additives Series*, 1972, No. 4.

In some instances one or several of these courses of action may be required. In many instances it will be necessary to maintain some of the monitoring actions described previously to assess the effects of the control measures taken. In view of the dynamic nature of aquatic environmental pollution and the increase in the amount of knowledge available in this field, public health agencies at all levels need to keep these matters under constant review. Environmental investigations within the general framework of those listed above should be considered whenever new areas or new species are being exploited.

2. PRINCIPAL HUMAN DISEASES RESULTING FROM INGESTION OR CONTACT WITH FISH AND SHELLFISH

Fish and shellfish not only transmit diseases to man but are themselves subject to many diseases, However, only a small number of these have any public health significance. Details of the principal fish- and shellfish-borne diseases caused by biological agents recognized in man are summarized in Annex 1 (Tables 1 and 2).

A general classification of food-borne diseases based on that used by the Joint FAO/WHO Expert Committee on Meat Hygiene [1] has been adapted to those diseases associated with fish and shellfish.

2.1 Classification

The diseases caused by fish and shellfish may be broadly classified into two groups : (*a*) those mainly affecting the consumer, and (*b*) those causing occupational diseases among people employed in the fishing industry.

Diseases mainly affecting the consumer

(1) *Bacterial*

(*a*) Bacterial infections (e.g., salmonellosis (003.0);[2] typhoid fever (001); paratyphoid fever (002); *Vibrio parahaemolyticus* infection (005.8); and shigellosis (004)).

(*b*) Bacterial intoxications (e.g., botulism (005.1), and staphylococcal food poisoning (005.0)).

[1] *Wld Hlth Org. techn. Rep. Ser.*, 1962, No. 241.

[2] The figure in parentheses are the code numbers appearing in the *Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death*, 1969, Geneva, World Health Organization.

(c) Bacterial intravital intoxication [1] (e.g., cholera (000), *Clostridium perfringens* food poisoning (005.2)).

(2) *Parasitic* (e.g., clonorchiasis (121.1), paragonimiasis (121.2), diphyllobothriasis (123.4), and anisakiasis).

(3) *Viral* (e.g., infectious hepatitis (070)).

(4) *Intoxications due to chemical poisons* (e.g., chronic mercury poisoning (Minamata disease)).

(5) *Intoxications due to biotoxins* [2] (e.g., paralytic shellfish poisoning, tetraodon poisoning, and ciguatera poisoning).

(6) *Allergic reactions following ingestion.*

(7) *Undetermined etiology* (e.g., agents causing summer diarrhoea).

Occupational diseases

(1) *Secondary bacterial skin infections facilitated by mechanical injuries* (e.g., streptococcal and staphylococcal infections, and erysipeloid).

(2) *Bites and stings* (e.g., bites of moray eel, stings of some catfishes, and sting of molluscan gastropods (*Conus* spp.)).

(3) *Allergic reaction by contact with fish, shellfish, or fishing gear bearing marine organisms* (692.5).

(4) *Incidental diseases acquired through environmental conditions associated with fish handling and processing* (e.g., leptospirosis, schistosomiasis, and conjunctivitis).

2.2 Fish- and shellfish-borne bacterial infections and intoxications

In most countries where statistical data are available, bacterial infections constitute the largest proportion of fish- and shellfish-borne diseases. These infections are due either to direct contamination of the product with polluted water or to secondary contamination of the product during landing, processing, storage, distribution, or preparation for consumption. Direct contamination of fish and shellfish with polluted water is of

[1] Intoxication by toxin produced in the body by bacteria present in heavily contaminated foods.

[2] Marine biotoxins are naturally occurring toxins derived from marine organisms. They may be produced by marine organisms themselves or may be acquired from another living organism in the marine environment.

particular importance when these products are eaten raw or only lightly processed. Secondary contamination of the product is usually more frequent in countries where sanitary conditions are generally poor.

2.2.1 Vibrio parahaemolyticus *food poisoning*

Increasing attention has been focused on *V. parahaemolyticus* since 1957 when it was recognized as a cause of fish-borne food poisoning in Japan. Over 50% of all cases of food-borne disease in Japan, including many of the cases of food poisoning for which no specific cause has been ascertained, are now believed to be due to this organism. *V. parahaemolyticus* has been isolated in marine waters, sediment, and fish and shellfish in various parts of the world. Certain strains produce a haemolysin that was once considered to cause the food poisoning but it is now thought more likely that production of enterotoxin is the cause.

V. parahaemolyticus food poisoning seems to occur more often during warm weather and appears to be closely associated with the consumption of raw seafood. It has been shown that the number of the organisms present in the marine environment increases in warmer water. This vibrio multiplies in food materials more rapidly than many other pathogenic organisms, but is usually destroyed by freezing.

2.2.2 *Cholera*

The role of fish in the transmission of cholera has been the subject of much discussion but there is no evidence that contaminated fish are a cause of infection in man. However, epidemiological investigations in the Philippines have identified the consumption of raw shrimps as the cause of an outbreak of cholera.[1] Laboratory studies have indicated that *V. cholerae* persists in fish and shellfish at room temperature for 2–5 days and under refrigerated conditions for 1–2 weeks.[2]

2.2.3 *Salmonellosis*

Bacterial infections caused by salmonellae have been extensively reported in the literature. In warmer climates where there is intensive environmental contamination with animal and human excreta, the risk of infection is great. The risk is enhanced if the fish or shellfish are washed in polluted water.

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[1] Joseph, P.R. et al. (1965) Studies of cholera El Tor in the Philippines. 2. A restrospective investigation of an explosive outbreak in Bacolod City and Talisay, November 1961, *Bull. Wld Hlth Org.*, 33, 637–643.

[2] Araoz, J. de et al., (1970) Principles and Practice of Cholera Control, Geneva, *World Health Organization Public Health Papers*, No. 40.

However, fish and shellfish are not an important source of salmonellosis where there is adequate public health control on the gathering of fish and shellfish from polluted areas and where modern techniques of handling are employed.

2.2.4 *Botulism*

Of the seven types of botulinum toxin known, type E is the one most commonly associated with fish- and shellfish-borne intoxication, because *Clostridium botulinum* type E spores are widely distributed in both fresh and salt water in many parts of the world. Many cases of type E botulism due to fish and fish roe have been reported. The spores of type E organisms are more heat-sensitive than those of other types and most outbreaks have been identified with raw or improperly processed seafoods, such as fish or fish roe that has been fermented, smoked, or held in vinegar. The organisms of *C. botulinum* type E are capable of growth at temperatures of 3.3°C and above ; this is of great public health importance because *C. botulinum* type E is not proteolytic, and growth and toxin production in fish cause no change in its organoleptic characteristics.[1]

2.3 Parasitic diseases

Several helminths inhabiting fish as larval stages are capable of causing disease in human beings if they are ingested. Most of the fish-borne helminthoses of man have a limited geographical distribution. The food habits of the people in areas where such helminths are found are the main factors influencing the incidence of these diseases. Man becomes infected only if he ingests raw, insufficiently cooked, or improperly processed fish. Annex 1 gives a summary of characteristics of the important helminths affecting man, including geographical distribution.

2.3.1 *Trematodes*

Over 40 species of trematodes belonging to the genera *Opisthorchis*, *Clonorchis*, *Metorchis*, *Pseudamphistomum*, *Metagonimus*, *Clinostomum*, *Cryptophyetus*, *Echinochasmus*, *Paragonimus*, *Spelotrema* and *Heterophyes* have several epidemiological characteristics in common : their first intermediate hosts are molluscs, their second hosts are fishes or crustaceans, and their final hosts are humans or animals eating raw fish ; the cercariae leave the molluscs, penetrate the skin or gills of fish and encyst there or

[1] The Committee noted that WHO-supported studies on the prevalence in the population of type E *Clostridium botulinum* antitoxin are being undertaken in Japan.

in the flesh ; after a certain time the cercariae change into metacercariae that are infective for the definitive host.

In man many of these trematodes parasitize the bile ducts, liver, and intestine. Others such as *Paragonimus* may invade the lungs. They may also go to ectopic sites including the brain and heart. *Opisthorchis*, *Clonorchis* and *Paragonimus* are the most important genera because they are widespread and can cause serious diseases.

2.3.2 *Cestodes*

Plerocercoids of pseudophyllidean tapeworm species, among which the genus *Diphyllobothrium* is the most important, may reach man through consumption of raw fish. The biology of this group involves two types of intermediate host : copepods and fish.

The eggs from the adult parasite released in human faeces, or faeces of reservoir hosts, such as dogs, cats, foxes, leopards, mink, bears and pigs, must reach water to develop into embryos. If free-living copepods ingest the embryos, the latter develop into procercoids. When fish eat the infected copepod, the procercoids enter the blood stream and reach muscles, gonads, liver, and other organs, where they develop into plerocercoids. This larval form may be passed several times from small to larger fish until consumed by certain carnivorous species.

If raw fish muscle or roe containing the living plerocercoids reaches the intestines of the definitive mammalian host, the plerocercoids develop into the adult tapeworms that generally cause debility and anaemia.

Plerocercoids of species other than *Diphyllobothrium* are incapable of maturing to the adult tapeworm in man but migrate into the skin or subcutaneous tissues causing the condition known as sparganosis. Water containing procercoids, or infested copepods, and the meat of other animals are more frequent sources of this disease than fish.

2.3.3 *Nematodes*

Migrant larvae of several nematode genera (*Anisakis*, *Ancylostoma*, *Bunostomum*, *Contracaecum*, *Dioctophyme*, *Gnathostoma*, *Phocanema*, *Toxocara*, *Uncinaria*, *Porrocaecum*, *Angiostrongylus*, and *Capillaria*) may reach man when he consumes infected fish, terrestrial or aquatic molluscs, or crustacea either raw, slightly salted, pickled, smoked, or partially cooked. The adult roundworms live in the intestines, kidneys, or, rarely, other organs of fish-eating mammals, birds and, possibly, predatory fish. The eggs of worms must reach water to mature and hatch. Copepods, worms, or molluscs are the first intermediate hosts, and fish or amphibians, reptiles, birds, and mammals serve as the second and third hosts. In the inter-

mediate fish-host the larval nematodes are encysted in the abdominal cavity or in the lateral body muscles and no overt signs of disease are seen.

Man is an abnormal host for these nematode larvae and while they cause little damage in their normal hosts, which are well adapted to them, they may cause considerable damage in man.

Recently three diseases caused by nematodes have been reported.

(1) *Anisakis* larvae occur in many marine fishes. Man is infected by eating raw or improperly processed fish. Slightly salted raw herring is the most commonly reported source of infection. There is no obvious reaction in man when the first larvae migrate from the gut into the abdominal cavity, but subsequent penetration of other larvae at the same site induces a severe reaction as a result of the previous sensitization. This allergic reaction causes a localized enteritis described as eosinophilic phlegmonous enteritis.

(2) *Angiostrongylus cantonensis* is a common parasite of the lungs of rats in the Pacific Islands and South-East Asia. This parasite has been shown to cause eosinophilic meningitis in man. Its usual intermediate host is a slug or land snail, and occasionally the larva can pass through a paratenic [1] host such as freshwater prawn, land crab, and possibly bonito from which man is infected.

(3) The nematode *Capillaria philippinensis* has been recognized as causing a syndrome called intestinal capillariasis in man. It is a disease characterized by intractable diarrhoea with malabsorption due to atrophic changes in the intestinal epithelium produced by the parasite. The infection is believed to be caused by eating raw freshwater fish harbouring the eggs of the parasite. It is not known, however, whether the fish act as intermediate hosts or paratenic hosts. An unusual feature of the infection is that all stages of the parasite can be seen in the same infected person and therefore autoinfection is possible.

2.4 Viral diseases

Outbreaks of viral infectious hepatitis have occurred in Europe [2] and parts of North America [3] following the consumption of clams and oysters taken from seawater grossly contaminated with sewage. Although there

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[1] A paratenic host is a host in which the larval form of a parasite rests, thus prolonging the life-cycle without undergoing any further development. See also: Baer, J. G. (1951) *Ecology of animal parasites*, Urbana, University of Illinois Press.

[2] Roos, B. (1965) Hepatitis epidemic conveyed by oysters, *Svenska Läk.-Tidn.*, 53, 989–997.

[3] Mason, J. R. & McLean, W. R. (1962) Infectious hepatitis traced to the consumption of raw oysters, *Amer. J. Hyg.*, **15**, 90-98.

is a strong epidemiological association between the consumption of polluted shellfish and infectious viral hepatitis, the causative organism has not yet been isolated from such incidents. There is no evidence that shellfish taken from areas satisfying the normal bacteriological standards have caused viral hepatitis.

It was agreed by the Expert Committee that more information is needed on the public health significance of viruses present in fish and shellfish. The Committee noted that WHO started a Food Virology Programme in 1969 that includes: collection of information on the characteristics and occurrence of viruses in foods, elaboration of methods for detection of viruses in food, and research on the effects of various food-processing techniques on the survival or destruction of viruses in food.

2.5 Allergy

Some persons are sensitive to certain varieties of fish and shellfish from contact or ingestion but this condition is of minor public health significance.

2.6 Diseases of undetermined etiology

Several outbreaks of diarrhoea have occurred after ingestion of fish and shellfish. Their etiology has not been determined despite extensive laboratory investigations.

2.7 Occupational diseases

The commonest diseases to which people engaged in the fish industry are subject are discussed below.

2.7.1 *Dermatological conditions*

Secondary infection of hands with streptococci and staphylococci has been reported among workers in the fishing industry. Infection is facilitated by injuries sustained during handling of equipment. The disease erysipeloid is caused by infection with the organism *Erysipelothrix insidiosa*. Dermatitis may also be caused by contact with nets, ropes, etc., bearing marine organisms [1, 2] or by repeated handling of the salt and detergents used in processing. Dermatitis may be caused by contact with such things as seaweed and invertebrates, including jellyfish and cone shells.

[1] Beer, W. E., Jones, M. & Jones, W. E. (1968) Dermatoses of lobster fishermen, *Brit. med. J.*, 1, 807–809.

[2] Newhouse, M. L. (1966) Dogger Bank itch: survey of trawlermen, *Brit. med. J.*, 1, 1142–1145.

.7.2 *Bites and stings*

Bites and stings are known to occur from a variety of commercial and oncommercial species of fish taken during fishing [1] (dogfish, stingrays, atfish, etc.).

.7.3 *Incidental diseases*

Leptospirosis. Leptospires are frequently transmitted to man through kin contact with water contaminated by the urine of infected rodents and ther animals. Fish market workers may be occupationally exposed if here is standing water where they work and if rats are present, as these nimals are reservoirs of infection. Fishermen may also be infected while tanding in slow-moving or stagnant bodies of water.

Conjunctivitis. Conjunctivitis occasionally occurs in workers engaged in rocessing, probably due to the presence of irritant fluids, splashed during utting, etc., e.g., eel blood.

Other diseases. Infection with *Schistosoma* may occur in persons shing in contaminated waters.

3. PRINCIPAL DISEASES OF AQUATIC FOOD ANIMALS AND THEIR PUBLIC HEALTH SIGNIFICANCE

A few bacterial diseases and certain parasitic infections of fish are nown to be transmissible to man ; the known viral and mycotic diseases f fish and shellfish are not transmitted to man, however.

When considering fish and shellfish as food, their diseases are important or two main reasons : (1) the available quantity of saleable fish and shellfish ay be reduced ; and (2) the palatability or appearance of diseased fish may e impaired. Either condition may make fish unacceptable for human onsumption.

Diseases of fish and shellfish occur both in nature and during aquatic ulture. Diseases can become more frequent and severe among fish and ellfish subjected to culture, especially in its intensive forms. But man is ble to detect and control and sometimes prevent these diseases ; such ctivities cannot be undertaken in the natural environment.

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[1] See bibliography for additional information.

3.1 Viral diseases

One chronic and five acute fish diseases are known to be caused by viruses (lymphocystis disease, viral haemorrhagic septicaemia, infectious haematopoietic necrosis, spring viraemia of carp, infectious pancreatic necrosis, and Channel catfish virus disease). Viral etiology is suspected in several other diseases but not definitely proven. Some fish viruses belong to the same groups as human or warm-blooded animal pathogens (for instance the rhabdovirus which includes viruses of the rabies group), but so far none of them are known to be transmissible to man.

3.2 Bacterial diseases

Bacterial diseases of fish and shellfish are caused almost exclusively by microorganisms specific to this group of animals. These bacteria belong mostly to the same genera as pathogens of humans and of warm-blooded animals, such as *Vibrio*, *Mycobacterium*, and *Aeromonas*.

Human infections with *V. parahaemolyticus* occur after ingestion of raw, improperly cooked, or preserved fish and shellfish from contaminated areas in which these animals become passive or active carriers of the micro-organism. Limited information indicates that in nature *V. parahaemolyticus* may cause disease and mortality in some shellfish and experiments have shown it to be pathogenic for some fish. Further studies are needed to understand the etiology of the disease in man and to define the significance of *V. parahaemolyticus* in fish and shellfish pathology.

Fish mycobacterioses are chronic diseases affecting over 100 species of freshwater and marine fish, mostly those held in aquariums ; several species of mycobacteria are involved. One aquarium fish pathogen, *Mycobacterium fortuitum*, can cause infections of wounds in man. This disease called " aquarium disease ", is exceedingly rare and is characterized by cutaneo-lymph node mycobacteriosis. Another fish pathogen, *M. balnei* (synonym for *M. marinum*) has been isolated from human skin lesions and is the cause of swimming pool granuloma.

Infections by *Nocardia* spp., including *N. asteroides* a human pathogen, were diagnosed in marine and freshwater fish. There is no evidence so far that such infections can be transmitted from fish to man.

3.3 Mycotic diseases

Relatively few fish diseases are caused by fungus infections. *Ichthyophorus* or *Ichthyosporidium* disease and branchiomycosis are the most widely occurring primary fish mycoses. Aquatic moulds of the genera *Saprolegnia*

nd *Achyla*, and a few others, cause secondary infections in freshwater sh and their eggs. There is no evidence that fungal diseases of fish are ransmitted to man.

.4 Parasitic infections

Among the large number of protozoans, crustaceans, and different types f worm infecting fish and shellfish only a small number of the worms are f public health significance. Parasitic diseases of fish and shellfish are elatively well known and can be controlled in cultivated fish. None of he parasites that are primarily pathogenic to fish are known to be pathogenic o warm-blooded animals, including man.

Helminths inhabiting fish as larval stages and capable of causing infections and diseases in human beings have been mentioned in section 2.3. Some of these helminths can parasitize fish heavily and induce severe athological changes.

.5 Tumours

Neoplasms have been reported in a variety of fish species and neoplastic ransformations have been seen in all types of cell and tissue. Some types f tumour are peculiar to fish ; genetic, dietary, and environmental factors, iruses, carcinogenic substances, and trauma have all been implicated in heir etiology. Such disease conditions are not known to be transmitted o man.

Aflatoxin, which has been shown to be present in the ingredients of ome fish feeds used in aquaculture, can produce hepatomas in rainbow rout and in some other fish ; it may cause a similar condition in certain irds and mammals. There is no evidence that such fish are a health hazard o man, but there is need for further work to understand the factors associated with the development of neoplasms and tumours in fish and shellfish.

.6 Further work required

Many of the pathogens of man enter the aquatic environment, and lthough there is evidence that fish and shellfish may act as passive carriers, here are notable gaps in our knowledge of their particular ecology. There need to determine whether human pathogens entering the aquatic environent can multiply in fish and shellfish and to determine their epidemiogical significance. Such information is needed for *Salmonella*, *Pasteurella*, *eptospira*, *Vibrio parahaemolyticus*, *V. cholera*, *Mycobacterium*, and *ocardia*. Further work is needed to understand the factors related to

the presence in fish and shellfish of parasites, especially *Anisakis*, *Capillaria*, and *Angiostrongylus* that have only been recently recognized as human pathogens.

4. BIOTOXINS OF MARINE FISH AND SHELLFISH

Only a small proportion of the species of fish and shellfish taken for human consumption throughout the world contain biotoxins of significance to man. Such toxins are generally absent from fish taken in cold and temperate waters; they do occur at times in fish from tropical and subtropical waters, however, and may pose serious local public health problems. Molluscan shellfish from cold, temperate, and tropical waters may at times become toxic.[1, 2]

4.1 Toxins of invertebrate origin

Toxins have been reported to occur in many invertebrates, including bivalves, whelks, abalones, cephalopods, crabs, and lobsters, but few of the incidents have had wide epidemiological significance.

Paralytic shellfish poisoning (PSP) is probably the most important in this respect. Outbreaks have been reported in North America, Europe, Africa, and Asia. Filter-feeding molluscs taken for food (mussels, clams, oysters, etc.) may become toxic to man as a result of the accumulation of toxin derived from dinoflagellates. Certain members of this group become dominant in plankton when nutritional and climatic factors are favourable. The most common organisms associated with PSP are *Gymnodinium brevis*, *Gonyaulax catanella*, and *G. tamarensis*, although many other species have been described locally. All these organisms are widely distributed, but PSP occurs only when relatively large numbers are present. At times, discoloration of the seawater occurs leading to the development of a " red tide ". Seabirds and some fish (sand eels) may die from the presence of the toxin, indicating the build up of toxic plankton, but molluscs are the main route by which man is known to be affected.

Build-up of toxin in molluscs can take place over a few days, but, once it is absorbed, natural loss of toxin from animals may take several weeks.

[1] Bagnis, R., Berglund, F., Elias, P. S., van Esch, G. J., Halstead, B. W. & Kohei Kijima (1970) Problems of toxicants in marine food products. 1. Marine biotoxins, *Bull. Wld. Hlth Org.*, **42**, 69–88.

[2] Halstead, B. W. & Courville, D. A. (1965) *Poisonous and venomous marine animals of the world*. Vol. I. *Invertebrates*, Washington, D.C., Government Printing Office.

The toxin is a saxitoxin and is heat stable, highly toxic, and curare-like in activity. Small doses cause a tingling sensation of the mouth and lips, and larger doses may cause collapse, paralysis, and death. There is no known antidote.

The appearance of toxic plankton is sporadic and it is not always possible to know when shellfish are likely to become toxic. However, in several areas, where shellfish are harvested commercially, the populations of toxic species of dinoflagellates develop annually. In these areas, it is usual to monitor the toxin content of commercial species on a routine basis. When the concentration of toxin exceeds the accepted level, the taking of shellfish is prohibited until such time as the product becomes safe for consumption. Biological monitoring of the plankton is not a practicable way of assessing the risk that shellfish may be affected, as toxic plankton occurs only sporadically and shellfish remain toxic long after the toxic plankton has disappeared.

Other groups of invertebrates may become toxic but the precise cause of the toxicity is often unknown. Thus, some clams are reported to become toxic at spawning time, and some whelks may contain a toxin in their salivary gland. Intoxications following the consumption of cephalopods, abalone, crabs, and lobsters have also been reported.

Apart from PSP, the intoxication of man following the consumption of other invertebrates is generally local and sporadic and usually not a matter that is amenable to normal public health control measures. Further research is required to understand the causes and epidemiology of intoxications associated with the consumption of invertebrates that form important constituents of the diet. Such information is needed when new species are being exploited, or when new sources are being developed.

3.2 Toxins of fish

Only a relatively small proportion of the species of fish taken for human consumption throughout the world contain biotoxins of significance to man. Toxins do pose serious problems, however, in certain tropical and subtropical areas.

Intoxications following consumption of fish have been reported extensively in the literature [1] but the causes are diverse, and precise information is often lacking. However, certain types of intoxication are clearly defined.

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[1] Bagnis, R., Berglund, F., Elias, P. S., van Esch, G. J., Halstead, B. W. & Kohei Kijima (1970) Problems of toxicants in marine food products. 1. Marine biotoxins, *Bull. Wld Hlth Org.*, **42**, 69–88.

4.2.1 *Ciguatera poisoning*

This is probably the most widespread form of intoxication, usually occurring after the consumption of tropical fishes occurring in inshore waters. Over 400 species of fish, including snapper (*Lutjanidae*) and grouper (*Serranidae*) have been identified. The precise cause is not known, and food fishes may suddenly become toxic and remain so for years. It is possible that toxicity is associated with some component of the diet. Symptoms of the poisoning include mild paralysis and gastrointestinal disturbances and, in extreme cases, death. The toxin is heat stable, and because of the sporadic nature of toxin production and the absence of more detailed knowledge, public health control measures are not generally applicable.

In view of the increased catching of warm-water fish, it is recommended that further investigations should be made into the causes of ciguatera poisoning, so that effective public health control measures can be taken. It would be of considerable advantage to public health agencies if a laboratory test could be developed to determine accurately and quickly the toxicity of fish.

4.2.2 *Tetraodon (puffer fish) poisoning*

This is associated with the consumption of puffer fish mainly of the genus *Fugu* from the tropical regions of the Pacific, Atlantic, and Indian Oceans. The toxin is concentrated in the gonads and liver, and the toxin content varies with the season. These fish are caught and used as a source of food after removal of the organs containing the toxin. The toxin is heat stable. Intoxication causes serious disease with a high mortality rate. As the intoxication is associated with well-recognized species, public health control is possible and involves measures to ensure that toxic organs are removed before the fish are taken as food.

4.2.3 *Scombroid toxicity*

It has been reported by some workers that tunas, bonitos, mackerel, and related fish may at times become toxic as a result of improper preservation. The toxic principle is believed to arise following bacterial decomposition, and causes histamine-like symptoms ; it is heat stable. The risk of scombroid poisoning can be reduced by attention to the use of hygienic handling techniques to prevent bacterial decomposition of the fish. Further research is needed to understand the causes and control of scombroid poisoning.

4.2.4 *Other types of toxicity*

Toxicity of a sporadic nature has been reported with other groups of fish. These include the cyclostomes (lampreys), elasmobranchs (sharks

and rays), *Chimaera* (rat fish), and clupeoids (herrings, anchovies, tarpons, etc.). The causes of these intoxications are not known.

4.3 Control measures

Public health officials and fishery inspectors should be alert to the possibility of toxic fish species being landed and offered for sale in areas under their jurisdiction. Certain control measures may need to be implemented to prevent the catching and consumption of toxic fish. Consideration should be given to such measures as controlling the area or season of catch and the evisceration of toxic organs. No methods exist for the detoxification of toxic fish and there is a need for the development of efficient detoxification techniques.

Particular caution is needed when new species of tropical fish are caught and used for food, in view of the large number of toxic fish species that have been reported from tropical regions. An epidemiological survey of the local residents may be carried out to determine whether consumption of a particular kind of fish is safe.

Public health measures for the surveillance of molluscan shellfish containing biotoxins involve monitoring the catching areas known to be seasonally affected. Established testing programmes and laboratory procedures have been used effectively in many parts of the world where this problem occurs. These programmes involve sampling selected shellfish at key stations and closing affected waters to further harvesting when shellfish biotoxins exceed acceptable levels. Other observations such as the presence of red or discoloured water, or dead or dying seabirds may be indicative of an approaching toxic bloom of marine dinoflagellates.

5. EPIDEMIOLOGICAL INVESTIGATION OF FISH- AND SHELLFISH-BORNE DISEASES

5.1 General remarks

Recommendations for epidemiological investigations to be made following outbreaks of food poisoning have been comprehensively dealt with in several previous publications.[1] Details of fish- and shellfish-borne-diseases of man caused by biological agents are summarized in Annex 1.

[1] For further information see : International Association of Milk, Food and Environmental Sanitarians, Inc. (1966) *Procedure for the investigation of food-borne disease outbreaks*, 2nd ed., Shelbyville, Ind., USA ; Communicable Disease Center, Department of Health, Education, and Welfare (1972) *Guide for investigating food-borne disease outbreaks and analyzing surveillance data*, Atlanta, Ga., USA ; *Wld Hlth Org. techn. Rep. Ser.*, 1968, No. 399.

Investigations pertaining to fish- and shellfish-borne outbreaks do not differ greatly from those investigations that are made following outbreaks of disease from other foods, and the methods applicable to other foods can be followed.

In the investigation of fish- and shellfish-borne disease, knowledge of the environmental aspects of local fish production, and fish-eating habits may be of assistance. For example, if raw fish is known to be consumed during the summer months, attention might be directed to *Vibrio parahaemolyticus* as a possible cause of outbreaks of gastroenteritis. Where acute toxicity occurs, the knowledge that toxic fish species are eaten would be of assistance.

Investigations should be carried out as rapidly as possible in order to identify the causative food, to obtain samples for analysis, and to determine the factors that led to the infection. Information obtained may be used to prevent further cases and may be valuable for administrative guidance in planning control methods. Careful investigation may also help identify etiological agents where these have not been previously recognized.

On being notified of a food-borne disease outbreak, public health officers should obtain information from all possible sources to determine the extent of the outbreak. If possible, the total number of persons affected, and their occupations and ages should be ascertained. Domestic animals are often fed on fish scraps, and enquiries about subsequent diseases in the animals might provide useful additional information.

The history of each affected person, including the time and date of onset of disease, and the most characteristic symptoms, should be recorded. Appropriate laboratory specimens such as faeces, vomitus, and blood should be taken. Specimens of liver, spleen, and gastrointestinal contents should be obtained for analysis from fatal cases.

To identify the cause of the outbreak, enquiries should be made at the place of consumption, to determine what was eaten and whether the meals were eaten in common with others who were affected.

In family or small community outbreaks interrogation of the patients may quickly reveal the nature of the food poisoning and indicate the meal and the article of food responsible. In large outbreaks where several items of food may be involved, the identification of the offending food item may not be so easy because contamination of one food by traces of another may occur before or during presentation to the consumers. The enquiry may be complicated by lapses of memory or even bias in history taking. This may be overcome by comparing the attack rates of those who ate a specified food with those who did not. When this procedure is used in large outbreaks it may suffice to obtain the relevant information from a sample of those persons consuming the meal.

Samples for laboratory examination should be obtained as quickly as possible ; these should include food, food remains, swabs from tables and utensils, and if possible, portions of the raw ingredients from which the food was prepared.

Attempts should be made to ascertain the manner in which the food became contamined. All food-handlers involved in preparation of the meal should be questioned about current and past illnesses. Samples of faeces, nasal swabs, etc., should be taken for laboratory examination.

All stages in the preparation of the food should be considered. When fish or shellfish are implicated, attempts should be made to trace the source of these items, and specimens should be obtained from the natural or artificial habitats. In addition, it might be necessary to take specimens of seawater and other environmental samples.

5.2 Laboratory aspects

Laboratory examination should be directed to the identification of those agents indicated by the nature of the symptoms, by the incubation period of the cases, and by the suspected food. If there are no clear indications, it might be necessary for laboratory examinations to be made for a wide range of agents associated with food poisoning.

Laboratory investigations might include microbiological, biological, toxicological, and chemical tests or combinations of these. Where gastroenteritis is thought to have been caused by fish or shellfish the laboratory investigation should include specific tests for *V. parahaemolyticus*, because routine laboratory media do not always support the growth of this organism. For this purpose a medium supporting the growth of moderately halophilic bacteria [1] should be used. In many countries, the reported outbreaks of fish- and shellfish-borne diseases are of unknown etiology ; when laboratory facilities permit, a search should therefore be made for hitherto unidentified pathogens.

When incidents involving fish or shellfish occur in areas where there are known to be fish parasites dangerous to man, adequate parasitological investigations should be carried out. These diseases are often insidious in onset and it is difficult to trace infection to a particular meal. However, many of the fish-borne parasites are derived from particular species of fish. Immunological tests developed for the diagnosis of some of these

[1] For more information on laboratory cultivation and identification, see : Sakazaki, R. (1967) *Isolation and identification of* Vibrio parahaemolyticus. In : Fujino, T. et al., Vibrio parahaemolyticus, Tokyo, Naya Shoten.

infections in man, may be used for surveillance of some species, i.e., *Paragonimus* and *Clonorchis*.[1]

When symptoms are believed to have been caused by fish and shellfish biotoxins, it is essential to identify the kind of fish or shellfish and to determine the area in which it was caught.

When environmental contamination results in chronic intoxication of fish or shellfish with chemical substances, epidemiological investigations should include field monitoring operations to assess the concentration of these substances in fish and shellfish taken from the area, the amounts of fish and shellfish consumed, and the concentration of these substances in the water. Attempts should also be made to determine the extent of clinical and subclinical effects on the population exposed.

5.3 Notification

Notification of food-borne disease outbreaks is compulsory in some countries of the world; in other countries, although notification may be incomplete, reliable information is sometimes available with regard to the pattern of food-borne diseases. Unfortunately, in many countries the incidence of food-borne disease is not known because notification procedures are inadequate or do not exist. In these countries, therefore, it is necessary for the notification system to be improved and for the larger outbreaks to be investigated with laboratory support, particularly when several persons show clinical symptoms. Such action would allow the epidemiological pattern of food-borne diseases to be established, and so facilitate future epidemiological investigation in the country.

The minimum requirements of an effective notification system should include information on the :

circumstances (community banquets, meals in restaurants, home outbreaks, etc.) ;

total number of persons affected in relation to those at risk ;

food concerned and its preparation ;

specific bacterial, viral, parasitic, or toxic agent detected by laboratory examination ; and

source of contamination of the food (animal or human cases or carriers, polluted water, etc.).

[1] See third report of the Joint FAO/WHO Expert Committee on Zoonoses, *Wld Hlth Org. techn. Rep. Ser.*, 1967, No. 378.

6. THE SAFE HANDLING OF FISH AND SHELLFISH AND THEIR PRODUCTS [1]

Fish and fishery products have a relatively safe record as far as transmission of disease is concerned although public health problems do arise in special circumstances. This safety is due at least in part to the necessity for preservative techniques to maintain the eating quality. There are, however, potential health hazards, particularly when changes or new processes are introduced. In these circumstances, care must be taken to ensure that the new product does not carry an increased health hazard. For example, recent changes in the preparation of smoked fish, i.e., a reduction in the salt and smoke contents, as a response to changes in public taste, have made these products more vulnerable, particularly in respect of *Clostridium botulinum* poisoning.

This section deals mainly with public health problems associated with the handling and processing of fish, but also applies to those shellfish, such as shrimps and crabs that are handled and processed in a similar manner. Fish that are eaten in the raw state require special attention and are considered in section 6.7. Specific problems associated with molluscan shellfish are considered in section 7.

In general, the types of microorganism and the numbers present in fish and shellfish are influenced by the environment from which the fish were obtained and the standard of sanitation during the subsequent handling, processing, and storage.[2]

The bacterial flora of freshly caught fish and shellfish generally contains the same genera, though the proportions of the different genera may vary widely. These are the Gram negative genera *Pseudomonas*, *Moraxella*, *Acinetobacter* (formerly called *Achromobacter*), *Vibrio*, *Aeromonas*, *Flavobacterium*, and *Cytophaga*, and the Gram positive genus *Micrococcus* and the coryneform group. When the fish or shellfish are caught close to land, organisms of terrestrial origin will also be present in appreciable numbers. Some of these belong to the genera already mentioned but significant numbers of aerobic sporeforming bacilli of the genus *Bacillus* may also be found. Organisms of faecal origin will be present when the fishing grounds are close to sewage outlets.

Most of the undesirable organoleptic changes occurring *post mortem* in fish result from the growth of bacteria ; the kind of bacteria and their

[1] See also : FAO (1973) Code of practice for fresh fish, *FAO Fish. Circ.*, No. C318.

[2] A detailed study and a comprehensive bibliography dealing with the bacteriology of fish spoilage is to be found in : Shewan, J. M. & Hobbs, G. (1967) The bacteriology of fish spoilage and preservation, *Prog. ind. Microbiol.*, 6, 169–208.

rate of growth will depend chiefly on the storage temperature. For example, cod spoils about twice as fast at 4°C as it does at 0°C. It is therefore most important to chill fish and shellfish quickly to the temperature of melting ice. At this temperature, spoilage is delayed. If the temperature is reduced below −1°C, the product may be damaged because of partial freezing. In practice, it is extremely difficult to control the temperature so precisely, but a range of −1°C to + 2°C throughout the fish can usually be achieved.

When fish and shellfish are stored in ice the spoilage flora is *Pseudomonas*, *Moraxella*, and *Acinetobacter*, the organoleptic spoilage changes being brought about chiefly by organisms of the genus *Pseudomonas*. The Gram positive flora grow slowly if at all at this temperature and hence are only of importance when fish is stored without chilling.

The flora of freshly caught fish from tropical waters is composed of the same genera as that of fish from temperate waters ; however, the proportion of mesophilic strains is much higher. This is of practical importance in that chilling of fish from such waters has a much greater effect and they have a much longer shelf-life. The flora responsible for eventual spoilage is, however, the same.

The intestines of fish contain large numbers of bacteria as well as active digestive enzymes. Even when fish are stored chilled the digestive enzymes may cause rapid digestion of the belly wall and hence rapid invasion of the flesh by spoilage bacteria. Where practicable fish should be eviscerated soon after catching. With most smaller species this is not feasible and they have to be handled with particular care to prevent spoilage.

Some fish (carp, trout) and shellfish (lobsters, oysters, etc.) are normally sold alive and special methods of handling are required (see sections 6.6, 6.7, and 7–7.2).

Usually only fish and shellfish caught in polluted waters carry bacteria pathogenic to human beings. Two species of bacteria are, however, found in fish from unpolluted water : *Clostridium botulinum* and *Vibrio parahaemolyticus*. Both these species can be present on freshly-caught fish although their distribution in different parts of the world is extremely varied. The numbers of these organisms present on fish and shellfish when caught are always small, and they cannot be detected without the use of special media and techniques.

6.1 Catching

The method of catching fish and shellfish may have a significant effect on the microbial flora. Trawling with a net on the sea bottom results in the fish or shellfish being dragged along the bottom for as long as 3–4 hours. Sediments usually contain large numbers of bacteria and this method of

fishing may increase the numbers on the skin of the fish by as much as 100 times. The organisms present in sediments are usually of the same genera as those already present on the fish. Fishing with different types of pelagic gear such as midwater trawl, drift net, floating gill net, purse seine, or with floating line methods does not have this disadvantage. However, when any kind of net is hauled out of the water and placed on board the ship, individual fish are subjected to pressure and the intestinal contents may be expressed on to the skin of surrounding fish. If the fish are brought up from deep water the intestinal contents may be expressed because of sudden expansion of the swim bladder. In either case, any pathogenic microorganisms present in the gut of the fish will be spread throughout the catch.

Fish decompose extremely rapidly in warm climates. Where shade temperatures over 30°C are common, some fish spoil so quickly that they may deteriorate, and in some instances become unacceptable, within a few hours after death unless appropriate preservative measures are applied.

In many commercial methods of fishing the fish are killed and may remain in the water for appreciable lengths of time. This is particularly true of gill netting and is more important in connexion with spoilage in tropical areas where fish may become unacceptable before they are taken out of the water.

6.2 Handling and storage on board ship

Handling and storage on board ship varies according to the method of catching, the type of fish, and the facilities available. Exposure to direct sunlight should be avoided. Similarly, physical damage should be avoided during handling since it assists in the spread and growth of microorganisms. In the case of line-caught fish, which are usually alive when they are hauled on board, it is desirable to stun the fish immediately after catching to prevent such damage.

Evisceration should be undertaken as soon as possible, in order to remove active digestive enzymes and large numbers of bacteria, preferably as soon as the catch comes on deck, and care should be taken to remove as much of the abdominal organs as possible. The main reason for gutting is to remove the stomach and gut which contain enzymes and microorganisms that cause softening of the flesh and that accelerate spoilage. Fish in which the gut is full of food spoil even more rapidly.

Although rapid gutting is desirable with most species, particularly in tropical countries, on some fishing vessels the catch cannot be gutted rapidly enough, and the advantages gained by gutting may be offset by loss of quality resulting from a rise in fish temperature. In such circum-

stances, it is recommended that the fish should be placed under cover and chilled quickly. Where rapid gutting is not practicable, the whole fish should be washed as soon as possible after they are hauled on board.

Much of the contamination from the sea bottom and from the intestines can be removed by washing with clean seawater. An efficient washing machine may reduce the numbers of bacteria present on the skin of fish by 95%. Fish should be chilled rapidly in melting ice or refrigerated seawater and should be stored so that the temperature does not rise. Ice made from clean freshwater or seawater will have a bacterial population similar to that of the water it was made from. Hence ice made from potable water will not contribute significantly to the bacterial population of the fish. Ice that has been stored on board ship, however, can contain large numbers of bacteria unless the fishroom is properly cleaned. These organisms are mostly psychrophilic spoilage bacteria originating from previous catches of fish. For further technical details reference should be made to the *Code of practice for fresh fish*.[1]

Freezing retards bacterial growth almost entirely. Some bacteria will survive, however, because of the protective effects of fats and proteins, and these organisms may be involved in subsequent spoilage. Prior to freezing the problems of contamination are similar to those described for chilled fish. Generally, chilling prior to freezing has been found to be beneficial because of the time interval between catching and freezing. Chilling can be achieved with ice but refrigerated seawater is usually more convenient. Some species of fish must be held at chill temperatures for at least 30 minutes to permit proper bleeding of the fish.

Because of the nature of the environment on board fishing vessels and the close proximity of man, bacteria of public health significance, resulting from handling and contamination, can sometimes be detected on the fish at this stage by means of special techniques.

6.3 Landing

When fish and shellfish are unloaded in port they should be protected from heat, particularly from direct sunlight.

When fish have been boxed with ice on board ship, the boxes can be unloaded with the ice still present to maintain the low temperature. Fish stored on board ship in bulk with ice or in refrigerated seawater should be unloaded at the port into clean containers. Generally, the ice is removed at this stage to facilitate weighing, sorting, etc. These procedures should be followed without delay by reicing to avoid any unnecessary rise in

[1] *FAO Fish. Circ.* No. C318, 1973, Rome.

temperature. A rise in fish temperature at this stage can influence the subsequent shelf-life.

Fish should be moved from the fish market as quickly as possible. Direct consignment of fish and shellfish to processors eliminates many of the hazards involved in exposing the fish for sale in the market but in certain countries this is not possible because of national legislation. Fish frozen on the ship is generally transported direct to a cold store and no special microbiological problems exist at this stage.

During handling, unloading, and exposure of fish in the markets, particular attention should be paid to the prevention of contamination or infestation by direct or indirect contact with rats, seabirds, domestic animals, etc. Further contamination with organisms of public health significance may occur during the various stages of processing and an increase in the numbers of coliform bacteria can often be demonstrated although the numbers are usually still very low. Under conditions of bad hygiene this contamination can be serious.

6.4 Processing

Processing of fish includes methods of preservation, such as chilling, freezing, canning, smoking, or salting and the production of manufactured products, such as fish cakes or fish fingers. Fish should be moved through processing chains quickly to avoid any unnecessary rise in temperature. Processing should be in accordance with the recommended international code of practice.[1]

6.4.1 *Chilling and filleting*

Fish to be offered for sale whole or filleted should, whenever possible, be maintained at a temperature of about 0°C. Although filleting machines are used, much filleting is still carried out by hand. In such cases, it is recommended that fish should be placed in a trough with cold running water while waiting to be filleted. The fillets should be washed and repacked with ice or frozen. The use of filleting troughs with static water at ambient temperature should be discouraged as this practice can lead to the development of very large numbers of bacteria, which contaminate the fillets.

Machine filleting is generally a more acceptable process but many machines are difficult to keep clean. Frequent cleaning avoids the accumulation of fish slime and fish waste and the associated microorganisms.

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[1] Joint FAO/WHO Food Standards Programme. Codex Alimentarius Commission (1969) *Recommended international code of practice. General principles of food hygiene*, Rome, FAO (CAC/RCP 1–1969)

In some countries the use of antibiotics is permitted, in order to extend the shelf life of chilled fish. Where antibiotics are used, particular attention should be paid to the recommendations of the Joint FAO/WHO Expert Committee on Food Additives.[1]

6.4.2 *Freezing and thawing*

Freezing and cold storage usually present few microbiological problems. However, when these processes are improperly used, the fish may deteriorate because of changes in texture, for example.

Thawing of frozen fish may be carried out in a relatively uncontrolled manner by leaving blocks of frozen fish to thaw at ambient temperature or by controlled exposure to warm air or warm water. However, if thawing is not undertaken carefully, rapid growth of bacteria and contamination can occur during the process. Fish may also be contaminated while in the warm air or warm water thawers, which rapidly become contaminated themselves. Because of the prevailing temperature conditions, mesophilic bacteria, chiefly spoilage bacteria, usually multiply and contaminate subsequent lots of fish. When present, bacteria of public health importance can also multiply under such conditions.

Parasites may be destroyed by freezing and cold storage, and fish from areas where parasites dangerous to man occur should be frozen whenever possible.

6.4.3 *Salting*

Salting is a process often used for products that are eaten without cooking. Different products vary greatly in the amount of salt they contain : some are also dried, and some undergo fermentation. The microbial flora of such products is derived from the fish, from subsequent handling, and from the salt or brine used in the process. Although the salt content of most products is too high for food-poisoning bacteria to develop, this is not so for all products and some therefore require careful handling.

A concentration of 9–10% sodium chloride inhibits the growth of all known food-poisoning bacteria with the exception of *Staphylococcus aureus*. However, spoilage of salted fish caused by two other organisms requires special mention. These are conditions known as " pink " caused by pink halophilic bacteria and " dun " caused by halophilic moulds of the *Sporendonema* or *Oospora* genera. Both originate from the salt used in the curing process, but these types of spoilage can be readily controlled by refrigerated storage.

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[1] *Wld Hlth Org. techn. Rep. Ser.*, 1969, No. 430.

When a fermentation stage is included, the conditions of fermentation must be carefully controlled to prevent the growth of undesirable spoilage organisms and the development of a potential health hazard.

6.4.4 *Smoking*

The main aim of smoking is not to preserve the fish but to give flavour and colour. Both eviscerated and uneviscerated fish are smoked. Prior to smoking, the fish is usually subjected to brining. The most common methods include cold smoking, in which the fish reaches a temperature of 15–30°C, and hot smoking in which the fish temperature may reach 90°C. During smoking, the flora of the fish is changed markedly, most of the bacteria present in the finished product being either halotolerant or halophilic, Gram positive coryneform bacteria or micrococci being predominant. For the most part these organisms originate from the fish itself or from the salt or brining tanks.

Subsequent spoilage of smoked fish occurs as a result of the proteolytic activities of these bacteria, although chemical oxidation of fats may become significant. In addition, smoked fish may undergo spoilage by the action of moulds, including *Penicillium* spp., and other microorganisms.

Food-poisoning bacteria such as *Staphylococcus aureus*, *Clostridium botulinum* and *C. perfringens* may be found in smoked fish. When the salt content is low enough these organisms are able to grow and produce toxin whether the product is vacuum packed or not. This may become a public health problem when the product is eaten without further processing, for the normal spoilage flora is inhibited by the salt and the smoke constituents whereas *C. botulinum* and some other bacteria are often still able to grow. These products may become highly toxic yet still be organoleptically acceptable as some toxin-producing strains of *C. botulinum* are non-proteolytic.

6.4.5 *Dried fish*

Although drying can successfully inhibit food-poisoning organisms, its effect on the microbial flora is limited. Secondary contamination may present a further hazard particularly during open-air drying. During drying, fish should not be placed directly on the ground and should be protected from secondary contamination by animals, birds, insects, and man. Infestation by insects is a particular problem with this type of product and further research into its prevention and control is required. Adequate facilities should be provided for storage and packaging and where economically feasible mechanical drying should be employed.

6.4.6 *Marinades*

The preservative factors in marinades are acids and salts ; to be effective against food-poisoning bacteria the pH must be below 4.5. Even under these conditions it is possible that parasites may survive and additional processing may be required. It is essential that fish to be treated by this process should not be subjected to secondary contamination, for the final product is often eaten without further treatment.

6.4.7 *Canning*

Canning carried out according to the *Code of practice for canned fishery products*[1] (under elaboration within the FAO/WHO Food Standards Programme) will result in a product without any public health hazard. However, with all canned foods, health hazards will arise if processing is not properly controlled.

6.4.8 *Manufactured products*

Fish coated with batter and products in which fish is an ingredient have the flora contributed by the additional raw materials. For instance, potatoes and spices used in the manufacture of fish cakes can contribute significant numbers of aerobic sporeforming bacteria of the genus *Bacillus* which in some cases can cause food poisoning.

Where batter enrobing (coating) machines are employed in which the batter can recirculate throughout the working day, the batter reservoir should be refrigerated because at ambient temperatures it can rapidly acquire a high bacterial count often with large numbers of coliform bacteria and small numbers of *Staphylococcus*.

In addition to brine and batter, many other " dips " are used in the processing of a variety of products. These include polyphosphates, citric acid, ascorbic acid, monosodium glutamate and a variety of dyestuffs. Bacteria can multiply in most of these dips and cause contamination of subsequent batches of fish or shellfish.

There is a wide variety of manufactured food products and a more detailed discussion of the hygienic practices recommended for such foods can be found elsewhere.[2]

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[1] FAO (1973) Code of practice for canned fishery products, *FAO Fish. Circ.*, No. 315.

[2] Riemann, Hans, ed. (1969) *Food-borne infections and intoxications*, New York and London, Academic Press ; WHO Expert Committee on Microbiological Aspects of Food Hygiene with the participation of FAO (1968) *Wld Hlth Org. techn. Rep. Ser.*, No. 399.

6.4.9 *Fish meal*

An appreciable proportion of the world's catch of fish is used for the production of fish meal which is then used primarily as animal feed. Secondary contamination, particularly with *Salmonella*, often occurs during handling and distribution and this gives rise to a potential public health hazard. The hazard may be widespread because large quantities of fish meal are involved in international trade.

Good plant sanitation, especially with respect to handling the end product, together with the use of pasteurization processes can minimize this problem.

6.4.10 *Transport and distribution*

During transport and distribution it is necessary to maintain the correct temperature and to prevent further contamination of the product. Efficient use of ice is generally practicable but by no means universally applied. There is wide use of insulated and refrigerated container transport, which is designed to keep products cool but not to result in further cooling.

Vehicles and containers should be designed in a way that facilitates cleaning and disinfection. At the present time the design and operation of vehicles and containers, and the facilities available at retail outlets vary widely, even in the more developed countries. A review of the methods at present in use would be of great value to those countries wishing to improve their methods of handling.

6.5 Special problems of mass production

The main problems in fish processing factories concern the accumulation of fish slime and waste, with their associated bacteria, on equipment and surfaces generally. Since much of the equipment and working surfaces are at ambient temperature, microorganisms, including those of public health significance, may multiply rapidly.

The centralization of food preparation and distribution in canteens and cafeterias is increasing and ready-to-cook meals are often prepared in prepacked form. In these circumstances, large numbers of consumers may be at risk and even stricter precautions are therefore necessary. The concentration of processing in large units, however, makes it possible to use modern techniques of handling and modern equipment, to improve quality control, and to employ skilled staff who understand and implement the principles of fish and shellfish hygiene.

6.6 Handling of live fish and shellfish

Some Crustacea, such as lobsters and crabs, are held in flowing seawater for considerable periods while on fishing vessels or in intertidal or land-based storage facilities. The water pumped into the wells of fishing vessels during transport and the water used in land-based facilities should not be contaminated. This implies that fishing vessels sailing through contaminated water should aerate the water already in the well rather than continue circulation. Care must be taken to ensure that secondary contamination does not take place and land-based facilities should, whenever possible, use cold water (at about 5°C).

During transportation of live fish, chemicals may occasionally be added to the water to prolong their survival. Anaesthetics, disinfectants and antifoam agents are employed. Their use should be carefully evaluated and regulated, and the residues of such substances should not be present in significant quantity in fish for human consumption.

6.7 Handling of fish for consumption raw

Fish and shellfish eaten raw or lightly processed pose a special public health problem. This may arise from the presence of undesirable organisms when the fish and shellfish are caught or as a result of secondary contamination. These organisms may be derived from the waters in which the fish were farmed as a result of pollution by wastes from man, animals, or birds, and may include viruses, bacteria, and parasites. Particular care must also be given to handling and processing techniques, and attention must be directed towards controlling the sources of such fish. The special public health problems arising from the catching and handling of molluscs that are to be eaten raw or lightly processed are dealt with separately in section 7.

Fish intended for consumption raw should not be harvested from areas subjected to unacceptable levels of sewage and other contamination ; such areas more frequently occur in coastal and estuarine waters, and in rivers and lakes. It is difficult to control the harvesting of fish subject to such contamination because of their mobility.

Fish for consumption raw should be subject to the most stringent conditions of hygiene at all stages of catching, transportation, storage, and processing ; particular attention should be given to the prevention of secondary contamination. Care should be taken to ensure that contamination does not take place on fishing vessels (from oils, human wastes, and other substances) and polluted seawater, such as that found in many harbours, should not be used for washing the catch. Fish to be consumed

raw should be handled quickly, and should be subject to the recommendations made in sections 6.1–6.3. Water used in processing should be of an acceptable quality.

7. SPECIAL CONSIDERATIONS WITH REGARD TO MOLLUSCAN SHELLFISH

The exploitation for human consumption of bivalve molluscs, such as clams, mussels, and oysters, poses special public health problems, many of which are being dealt with elsewhere.[1]

In many parts of the world these molluscs are important to the fishery industry because they are sedentary and grow in coastal and estuarine waters where they are often cultivated. Thus, large quantities of molluscs can be produced in relatively small areas, and have become an important source of marine protein. As the most fertile coastal and estuarine waters are often subject to pollution by sewage effluents and as a large proportion of the molluscs from these areas are eaten raw or only lightly processed, there is a risk that human enteric diseases may be transmitted. Diseases that have been transmitted by the consumption of polluted molluscan shellfish include, but are not limited to, typhoid and paratyphoid fever and infective viral hepatitis. Thus, particular care is required to ensure that molluscs harvested from such areas are suitable for human consumption, or are rendered safe by subsequent handling techniques.

7.1 Seawater quality

The suitability of raw shellfish for consumption without further treatment will depend upon the quality of the waters from which the shellfish are derived. Water quality can be assessed either by direct examination or by examination of the product, or by a combination of both methods. Bacteriological surveys should be made of the growing areas and of the shellfish to determine the degree of contamination, using suitable indicators, such as faecal coliforms or *Escherichia coli* as indicators of faecal contamination.

Shellfish taken from very lightly polluted seawaters are usually of an acceptable quality, and the presence of small numbers of faecal organisms in the waters should not be taken to imply that the area is unsuitable for

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[1] *The code of hygienic practice for molluscan shellfish* is being elaborated within the FAO/WHO Food Standards Programme by the FAO/WHO Codex Committee on Food Hygiene.

shellfish harvesting. Some national public health agencies have defined what is to be regarded as water of an acceptable bacteriological quality and thus the suitability of harvesting areas can be clearly established. Other national agencies define the acceptability of harvesting areas after bacteriological examination of harvested shellfish. The harvesting of shellfish from hygienically unacceptable areas should be prohibited except when the shellfish are subjected to approved treatment processes.

7.2 Treatment of molluscan shellfish

Wherever possible, molluscan shellfish resources should be located in areas where the product is acceptable for human consumption without further treatment. Where this is not possible, techniques should be used that ensure that the product becomes acceptable. Polluted shellfish may be made safe for human consumption by the use of heat treatment (boiling, steaming, canning, etc.). Where molluscs are to be marketed in the raw state, techniques exist for the removal of faecal organisms by natural processes. This can be achieved either by relaying the shellfish on the seabed in areas where the seawater is unpolluted, or by holding the shellfish in basins or tanks under conditions that allow the shellfish to remove polluting bacteria naturally. The latter process is known as purification or depuration.

7.2.1 *Relaying*

When bivalve molluscs containing faecal bacteria are relayed in the sea or in estuaries where there is no faecal pollution, the numbers of faecal organisms becomes greatly reduced and they become acceptable for human consumption. This process can be employed commercially, providing areas of clean seawater and suitable hydrographic conditions (salinity, protection from scouring currents or wave action, nature of the seabed) are readily available.

7.2.2 *Purification (depuration)*

The techniques employed vary widely but all use basins or tanks of seawater, in which the shellfish are held for several days. For purification to proceed, shellfish must be held in tanks of water under conditions that allow the shellfish to live or function normally. Ideally the tanks should be situated where clean seawater of adequate salinity occurs naturally. In practice, however, most purification plants are situated in polluted areas and the seawater used for purification is usually treated by means of chlorine, ozone, or ultraviolet light to remove faecal bacteria. The

public health agency identifying the need for such an installation should ensure that it conforms to certain design criteria and that its operation is under the supervision of skilled staff. Close public health control should be maintained over the operation of such a unit, by frequent inspection and bacteriological examination.

7.2.3 *The wider application of existing techniques*

Most of the methods employed for the public health control of molluscan shellfish are based on knowledge of temperate species and temperate waters. When it is proposed that new species, particularly those in tropical and subtropical areas, should be caught for food, investigations should be made to discover whether any special problems might arise. Public health agencies should survey the microbiological status of the areas in which the shellfish grow to determine their suitability for consumption. In some instances it will be necessary to modify the existing purification techniques to meet the requirements of different species or conditions, particularly in tropical waters. It is often dangerous to apply existing techniques to other species because of the physiological differences that exist even between species of the same genus. Subject to these provisions, public health agencies should encourage the use of purification techniques in areas where polluted resources are at present being harvested.

8. THE USE OF CERTAIN CHEMICALS AND FOOD MATERIALS IN FISH AND SHELLFISH CULTIVATION

In section 1 consideration was given to the effects of environmental pollution on the quality of fish and shellfish taken for human consumption. In that section, attention was directed towards the effects on quality of wastes intentionally released into the marine environment for the purpose of disposal. With the increasing use of aquaculture in fresh and marine waters, a wide range of substances is being added to water. In this section, attention will therefore be given to consideration of the public health significance of these practices.

Because of the wide range of substances and methods of application now in use only certain aspects can be discussed. However, it is considered that most of the principles involved will become apparent, and it should be possible for a public health authority to make its own assessment of the public health significance of new substances and new practices. The problems discussed in this section are more likely to occur when aquaculture is performed in tanks, particularly those with recirculation processes, in view of the relatively small volumes of water used.

8.1 Use of pesticides and herbicides [1]

Many of the areas of fresh and salt water used for aquaculture, such as rivers, ponds, lakes, rice fields, and tidal lagoons, are sometimes treated with herbicides to remove algae and other water plants. Molluscicides may be used in aquatic areas, or in lands draining into rivers or lakes to control intermediate stages of organisms parasitic to man or domestic animals. Several insecticides have been used to control parasitic diseases of fish and shellfish held in tanks and for the control of mosquitos in marshlands ; others may be used in estuaries or hatcheries to control predators and competitors of oysters, clams, etc.

The Expert Committee reviewed the effects that these substances may have on public health and recommended that wherever these or similar substances are used care should be taken to ensure that the substance is, (*a*) not persistent in the water or the food organism (i.e., it is biodegradable), and (*b*) not accumulated by food organisms and transmitted to man in significant quantities.

Where the use of persistent substances cannot be avoided, care should be taken to regulate the quantity used and the time of application to avoid making the product unsuitable for consumption. Restrictions may have to be applied several days, or several months before harvest, depending on the circumstances.

8.2 Foods materials used in fish and shellfish culture

Human and animal wastes are sometimes used to fertilize ponds in which fish cultivation takes place. This promotes the development of natural fish foods. With these practices there is a risk that the fish may be tainted, or more seriously, that they may transmit pathogenic organisms to man. Pathogenic viruses and bacteria may in some circumstances be reduced or eliminated from food species of fish by holding them in clean ponds for a sufficient time. However, this practice will not eliminate metazoan parasites. The use of these wastes should therefore be avoided as far as possible, and alternative ways of fertilizing the ponds, or of treating the wastes before use, should be considered. In view of the extensive use of sewage effluents in some countries, the Committee recommended that further studies should be made to determine the public health hazards connected with their use for fish and shellfish culture.[2]

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[1] For further details see : Safe use of pesticides, *Wld Hlth Org. techn. Rep. Ser.*, 1973, No. 513.

[2] The Expert Committee noted that a similar recommendation was made by the India–Pacific Fisheries Council at its Scientific Technical Session on Coastal Aquaculture and Environment in 1972 at Wellington, New Zealand.

Certain public health risks may also arise when fish intended for consumption are given foods containing fishmeal, or waste materials from food processing. These foods may contain organisms or substances that, even though not pathogenic to the fish, may be transmitted to man (enteropathogenic bacteria, parasites, etc.). Similar risks also occur where medicated feeds are used to control septicaemic bacterial diseases of fish. The Committee recommends that, whenever possible, these feeds should be administered only under defined conditions that have been agreed by the public health agency. These conditions should ensure that there is no harmful agent in the edible part of the fish when it reaches the consumer.

9. SPECIAL PROBLEMS OF FISH AND SHELLFISH HYGIENE IN WARM CLIMATES AND IN DEVELOPING COUNTRIES

In developing countries, considerable progress has been achieved during recent years with respect to the introduction of higher standards of hygiene, efficiency of handling, and preservation and processing of fish and shellfish, particularly when such products (fresh, frozen, canned, dried, salted, etc.) are being exported. However, fish and shellfish products in local or national markets have often not reached the same standard of hygiene. Many factors contribute to this phenomenon.

Developing countries are often characterized by a climate that makes the handling and preservation of fish and shellfish difficult. Furthermore, the resources required to create the conditions necessary to ensure correct handling of the fish (i.e., transport, improved design of boats and vessels, sufficient and regular supplies of electricity, good quality water, salt, and ice) are often lacking. This lack of resources is accompanied by a dearth of trained personnel, and perhaps, more important, by a lack of awareness of modern sanitary practices.

The health hazards resulting from inadequate handling and processing of fresh fish and shellfish have been well recognized in economically advanced countries but are less well recognized in developing countries where the rate of spoilage may be considerably faster.

Reports of infections, occasionally of an epidemic character, as a result of the unhygienic handling of fishery products have been well documented. Many of the incidents have arisen through inadequate handling on board fishing vessels or on shore, or have been associated with fish and shellfish derived from polluted areas. Others have resulted from the practice common in a number of countries, particularly in the Western Pacific region, of consuming raw, partially cooked, slightly salted, or smoked fish. Although the production and consumption of molluscan shellfish is

considerable in many countries in Latin America and South-East Asia, cleansing techniques, such as, relaying and purification, are little known. (See section 7.2.)

The problems of fish hygiene discussed in section 6 also relate to the developing countries. When considering what action might be taken to improve fish and shellfish hygiene in developing countries, it should not be forgotten that any proposals must take into account the local economic and social background and the dietary habits of the consumer. Education of the public generally, and of the personnel engaged in the industry at all levels of production, should be considered of prime importance.

Improvements in processing can be achieved most readily by modification and application of existing processes. For instance, many of the traditional fermentation processes can be improved both with regard to economics and public health.[1] The modification of traditional methods of treating fish does not require the consumer to change drastically his eating habits. In some cases, the knowledge and technology needed to achieve improvements in hygiene are available ; in others, however, further work is required.

The use of preservatives, such as antibiotics, in ice to prevent spoilage is not desirable. However, when their use cannot be avoided, a thorough examination of the practice should be made by the public health agency taking into consideration local conditions.

Perhaps the most important single factor that will improve the hygienic quality of fish and fish products is the introduction or extension of refrigeration facilities or the use of ice, especially on board fishing vessels. This technology is available and the limitations are entirely those of economics and education. Regional and national organization of landing and processing facilities and inspection and control services can substantially facilitate the application of better hygienic handling and processing methods.

10. PUBLIC HEALTH PROBLEMS ARISING FROM INTERNATIONAL TRADE

About two-fifths of the world fish and shellfish catch enters international trade, either fresh or processed. Fresh and frozen fish account for about one-third of the total export value of the international trade of fishery products. Crustaceans and molluscs, fresh or processed, account for roughly one-fifth of the world trade. The remainder is marketed cured, canned, or is reduced to fish meal, fish oil, etc.

[1] *FAO Fish. Rep.* 1971, No. 100.

Whereas for some countries export trade in fish is a major source of income, for many others the importation of fish and fish products amounts to about 0.5–1.0% of the total value of their imports. This implies that on the basis of value and volume the authorities of importing countries may be inclined to disregard or insufficiently appreciate the health hazards related to this kind of trade. Most countries make general provisions in their legislation for foods and, in addition, more detailed legislation for specific products or product groups.

With increasing international trade the need has been felt to harmonize this legislation on a regional and/or global basis. A number of international governmental and nongovernmental bodies are currently engaged in this work.[1]

To promote coordination in this work the Codex Alimentarius Commission was established in 1962 to implement the Joint FAO/WHO Food Standards Programme. By 1973 more than 100 countries had become members of the Codex Alimentarius Commission.

The purpose of the Commission's programme is to protect the health of consumers and to ensure fair practices in the food trade by elaborating a set of internationally adopted standards and codes of practice for the principal foods. In the work related to fish and fish products close cooperation exists between the FAO Department of Fisheries and the Codex Alimentarius Commission.[2]

The standards and codes contain a number of provisions including hygiene requirements. The minimum hygienic requirements that should be fulfilled for the product to be regarded as wholesome are stated in general terms.

In the course of the elaboration of various standards and codes by the Codex Alimentarius Commission and by other bodies, the urgency of establishing internationally acceptable methods for assessing the micro-

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[1] FAO/OIE/WHO Meeting on Basic Principles for the Control of International Traffic of Animals and Animal Products (1964) *Report of the Meeting..., 12–17 October 1964, Berne* (Meeting report AN 1964/9).

[2] FAO, in collaboration with a group of scientists and industrial experts, has published a "*Code of practice for fresh fish*" *and a* "*Code of practice for frozen fish*", which are of considerable value. At the request of the Codex Alimentarius Commission, FAO broadened the scope of these codes of practice by incorporating hygienic requirements along the lines proposed by the Codex Committee on Food Hygiene. The *Draft Code of Practice for Fresh Fish* (available as *Code of practice for fresh fish, FAO Fisheries Circular*, No. C318) and the *Draft code of practice for canned fishery products* (available as "*Code of practice for canned fishery products*", *FAO Fisheries Circular*, No. 315), which combine technological and hygienic requirements were submitted to the Codex Committee on Fish and Fishery Products for their consideration in October 1973. The *Draft code of practice for smoked fish*, the *Draft code of practice for shrimps and prawns*, and the FAO technological *Code of practice for frozen fish* have been developed along similar lines. Development of other codes for various fish and fishery products is planned.

biological quality of foods was realized. A number of specialized bodies are already active in the field. The Codex Alimentarius Commission aims at coordinating the work to establish certain reliable, reproducible, and practicable methods. As microbiological analysis is closely related to sampling, sampling methods are being examined at the same time.

Although national microbiological standards exist in some countries for fish and fish products, international standards are still required, particularly for those items for which there is considerable international trade. In particular, there is a need for hygiene provisions, including standards and trade specifications, for fish and fishery products intended for consumption without further heat treatment, i.e., raw fish and shellfish and some cured fishery products. These fishery products can present a very significant public health risk.

Under certain conditions molluscan shellfish of poor sanitary quality may transmit such epidemic diseases as typhoid fever or infectious viral hepatitis. In countries where appropriate control exists such infected products will not be marketed and exported. Furthermore, there may be significant risks associated with the introduction of fish meal and sun-dried fish products, as both may carry *Salmonella* and are subject to extensive international trade.[1]

Live and fresh fish and shellfish, and some of the products containing them, may sometimes transmit infections, pests, and parasitic diseases. A report concerning the resource aspects of the movement of live fish and shellfish intended for relaying or release in the sea has been made by the Working Party on the Introduction of Non-Indigenous Marine Organisms of the International Council for the Exploration of the Sea (ICES).[2] It is proposed that a Code of Practice should be produced to prevent the spread of pathogens of marine species; these include some pathogens of public health significance. The control of traffic in these marine organisms should therefore be regulated by the appropriate government services and their transport should be carried out in such a way as to avoid any risk of propagating disease.

Inspection and control of plants processing fish and shellfish and of their products should be an integral part of international trade. Some importing countries require fish and shellfish products to be accompanied by a certificate from the responsible agency in the exporting country. Such

[1] FAO/OIE/WHO Meeting on Basic Principles for the Control of International Traffic of Animals and Animal Products (1964) *Reports of the Meeting..., 12–17 October 1964, Berne* (Meeting Report AN 1964/9).

[2] Report of the Working on Introduction of Non-Indigenous Marine Organisms (1972) *ICES Cooperative Research Report*, No. 32, International Council for Exploration of the Sea, Charlottenlund, Denmark.

certificates should supplement but not replace the normal inspection procedures carried out by the public health agency of the importing country. The quality standards adopted by the exporting country for a certain product are often specified by the importing country.

11. FISH AND SHELLFISH HYGIENE INSPECTION SERVICES

The quantity and variety of fish products available to consumers are constantly increasing. In general, however, improvements in the quality and wholesomeness of fishery products have not kept pace with those of other competitive protein foods, such as meat and milk. This may be explained in part by the relatively low incidence of fish- and shellfish-borne disease and by the existence of local traditional habits of fish consumption. On the other hand, in spite of considerable interest in fish inspection, many countries still do not have any specific programme of inspection for fish and shellfish. The Committee therefore recognized that consumers of fish and fishery products often do not enjoy the same protection as consumers of other protein foods.

The objectives of a fish and shellfish inspection service are to assure the consumer a safe, wholesome, and acceptable product. There is increasing concern among some public health officials that fish and shellfish may present a health hazard because of changes of the aquatic environment in some places and as a result of the recent recognition of new human pathogens and of additional toxic species of fish and shellfish. The export trade in fish often depends upon the existence of a reliable and effective inspection service in the country of origin. The continuous operation of a recognized inspection programme supported by the responsible government agency is important in gaining and maintaining the consumer's confidence, particularly in international trade.

When fish or shellfish of poor quality are discovered by a receiving agency, an established inspection service should be in existence to bring about immediate corrective action. This will help to prevent loss of consumer confidence in fish and shellfish and economic damage to the industry. An effective and efficient inspection service can be instrumental in preventing such occurrences and can be helpful in lessening the effects of outbreaks of disease carried by fish and shellfish.

Public health problems may also be caused by fish and shellfish caught by individuals or small groups, either for a living or for sport. Inspection of such catches is very difficult but the inspection services should consider

the possibility of educating the population, including individual fishermen, and of carrying out surveys of waters, fish and shellfish in combination with controls on fishing in unsafe inland and coastal areas.

11.1 Organization of fish inspection services

The organization and resources required by a fish inspection service can be decided only in the light of local circumstances, taking into account the size of the industry, the variety of products, the prevailing health hazards, the geographical situation, domestic and foreign trade, and the local economy. The nature of the organization may be simple or complex, but must ensure that the products will not present a health hazard.

Resources should preferably be provided under government auspices but in some cases they may come from the industry, or be provided jointly, or come from other sources. Inspection services must be provided at a realistic cost to the consumer and the community.

The question of whether inspection programmes in general should be mandatory or voluntary is one that can be decided only in the light of existing local circumstances. However, provisions that safeguard health must be enforceable by law through appropriate regulations. Inspectors must have the authority to seize and condemn hazardous fish and shellfish products from market channels and to stop harvesting. Consideration should be given to the possible benefits to be gained by introducing regulations governing the quality of major export products. Together with these regulations, Codes of Practice should be evolved to deal with hygienic and technological aspects of fish and shellfish handling, processing, transportation, and marketing ; such codes can be easily modified and improved when necessary.

It is generally recognized that a fish inspection programme is most likely to succeed if it is developed as a cooperative effort between the government and the industry working in an atmosphere of mutual confidence and understanding. For this reason, liaison must be established with all sectors of the fish industry. Liaison with other regulatory bodies, including those concerned with health, fisheries, the environment, and commerce is necessary to ensure an integrated approach to the inspection programme. It is also important that liaison be maintained with export markets to ensure compliance with their regulations.

The delegation of responsibility for administration of a programme of fish inspection should be well defined and preferably identified with one agency.

The uniform and reasonable application of laws and regulations by the fish inspection authority is important to maintain mutual trust and con-

fidence with the industry. There is an obvious obligation on the part of inspection service authorities to inform and explain the hygienic requirements expected of members of the fish and shellfish industry.

Where possible, inspection should encompass all phases from cultivation and harvesting to the final distribution. Where there are limited resources, the inspection programme should be developed in stages starting with surveillance of critical points, such as landing and marketing places. Strict regulations as well as frequent and thorough inspections are necessary for fresh and frozen fish and shellfish that are to be consumed raw.

Inspection can more readily be undertaken, and the product will generally be of a better quality, in plants where the processing operation is well planned, and where the movement of raw materials and processed products through the plant is arranged systematically. Thus, whenever possible, the inspection services should advise plant designers at the planning stage, so that the processing arrangements ensure that the product is maintained at the highest quality through all stages of processing.

Canning of fish and shellfish requires essentially the same type of inspection as the canning of other protein foodstuffs. The inspection of semi-preserved products, such as salted or smoked fish, involves more specific problems. Some special types of product, typical of individual countries or regions, for which sanitary and technological standards do not exist, require special attention.

Consideration must be given to recruiting and retaining competent staff for the fish inspection service. In view of the wide range of problems involved in the control of fish and shellfish hygiene, it is necessary to employ personnel who have received specialized training in fields such as food technology, chemistry, microbiology, hygiene, epidemiology, and toxicology. Competent administrators are required to coordinate and supervise the technical activities of the service in the field, processing plant, and laboratory. Their work must be supported by people who have experience in hygiene concerning all aspects of the fishery industry.

11.2 Laboratory services

Laboratories are indispensable if the inspection service is to fulfil its responsibilities, particularly with regard to fish-borne disease surveillance. Collaboration must exist between the field inspection services and the laboratory services, for the microbiological assessment of fish and shellfish as food must be evaluated together with data relating to its source, processing, and handling and must take into account technological, environmental, and social influences.

The laboratory service should be adequately equipped and staffed t deal with samples taken by field inspectors. The tests should use standar methods whenever possible, and there should be adequate checks on th analytical procedures used.

It is most helpful if laboratory personnel participate with field inspecto in the early planning of field surveys or inspections involving large numbe of laboratory samples. The logistics of sample collection and shipmer and the ability of the laboratory to deal with them are important considera tions in successful planning of a comprehensive control programme.

The laboratory should be equipped to deal with organoleptic, micr biological, parasitological, toxicological, chemical, and physical tests, appropriate.

Organoleptic tests can be employed simply to reject fish unsuitable fo consumption or to grade fish. For grading, special facilities should b provided for preparation and presentation of the samples, and speci personnel trained in organoleptic assessment will be required.

Microbiological tests should be used to give a comprehensive analys of the product and also to obtain information on processing and transpo facilities and equipment, on water used for storing and transporting li fish and for cleaning operations, and on other ingredients added to man factured products.

Occasional microbiological examination is of limited value. Ideall the product and the handling and processing facilities should be sampl regularly from the time of catching to consumption. Regular sampli of raw materials, processing machinery, and products will establish t effectiveness of the quality or process control procedures employed. In pra tice, however, regular sampling of the finished product alone may adequate to guard against health hazards, although further examinati of raw materials and plant will be required to establish the source of a contamination by pathogens.

The scale of the laboratory investigations to be made in a particu circumstance will depend on whether the investigation is part of a rout control programme or designed to determine the cause of a specific pr lem. The number of samples from one source and the range of tests emplo as part of a routine control activity will be the minimum that is consist with achieving the objective, whereas an extensive range of tests a extensive sampling may be needed for specific enquiries.

Microbiological methods should also be used to investigate spoil or suspected spoilage in order to explain the causes and to contribute an assessment of the suitability of the product for consumption. microbiological tests should take account of the epidemiological probl at the stages of catching, processing, and consumption and should c

monly measure total viable counts—numbers of coliforms, faecal coliforms, and faecal streptococci — and specifically test for *Staphylococcus aureus*, *Clostridium botulinum*, *C. perfringens*, *Salmonella* spp., and *Vibrio parahaemolyticus* and parasites as required.

Chemical, physical, and toxicity tests should be used as appropriate to determine the level of freshness, the presence of potentially toxic materials (mercury, cadmium, lead, and biotoxins), and radioactivity.

Suitable tests and methods are available for some of these[1] but in many cases further work is required to devise new tests or to evaluate more thoroughly the tests or instruments already available.

Facilities should be provided for the recognition of poisonous fish and suitable experimental animals should be available for the assay of these biotoxins and microbial toxins.

12. REQUIREMENTS FOR TRAINING AND EDUCATION

There is reason for regarding food hygiene as a single subject because common principles underly all its many aspects. However, each of the specialized fields presents such complexities that each requires separate study. Furthermore, education and training should be suited to particular objectives; these may include research and technology, supervision and quality control, and objectives related to specific technical tasks. Courses should be designed for (*a*) the general food hygienist, (*b*) the specialized food hygienist, and (*c*) technicians and auxiliaries. Training will vary with regard to curricula, time, and study requirements in each of these categories, and may range from short courses and on-the-job training to education at the first degree and postgraduate level.

Education and training of personnel is essential for efficient control at all stages of fish and shellfish production from the point of view of hygiene and prevention of fish- and shellfish-borne diseases. Such control requires close interdisciplinary cooperation between workers in fields such as chemistry, epidemiology, hygiene, fish technology, microbiology, parasitology and toxicology. In a number of countries the education of specialists in fish and shellfish hygiene is not as well established as that of specialists in meat and milk hygiene.

Many undergraduate courses do not equip students to deal with all the problems involved in the control of fish and shellfish hygiene. The necessary further training is at present given to veterinarians, physicians,

[1] Evaluation of mercury, lead, cadmium and the food additives amaranth, diethylpyrocarbonate and octyl gallate, *WHO Food Additives Series*, 1972, No. 4.

sanitary engineers, sanitarians, and graduates in certain other disciplines

This arrangement has certain advantages, particularly for supervisor and coordinating personnel such as physicians and veterinarians, becaus fish hygiene must be assessed from the viewpoint of the protection of huma health. Considerable postgraduate training is necessary to achieve fu competence in the field of fish and shellfish hygiene.

However, it is also necessary to train competent technicians an auxiliaries at other levels. Such training may take place at technical inst tutes, but the basic training for qualified auxiliary personnel is usually unde the direct guidance of staff experienced in the field. A further effective for of postgraduate education, especially for those workers who already hav some experience, is by courses arranged by special institutes and centre Because of the rapid changes and developments in this field, refreshe courses should be available to all trained staff.

The FAO Technical Conference on Fish Inspection and Quality Control recognized the need for training at at least four levels for fish and shellfis inspection and quality control programmes. These include :

(1) plant operating personnel and fishermen ;

(2) sorters and graders ;

(3) regulatory inspectors and fishery officers ;

(4) supervisory personnel and quality control manager.

In many cases, the training should be carried out on the job. Howeve it should not be assumed that this type of training will be sufficient by itse for all types of personnel, in particular regulatory inspectors, fishe officers, supervisory personnel, and quality control managers. It is recor mended that training courses in technical institutes be developed particular for the training of regulatory inspectors and fishery officers.

The training of personnel at lower levels (plant operating personne fishermen, sorters, and graders) is often neglected. However, it is importa that these workers should be introduced to the basic principles of fi handling sanitation and the special technology of fishery operations. Pla managers and government organizations should provide this level training by means of prepared educational materials, in-service trainin and short courses.

Inspectors or fish hygienists must have a good knowledge of technolo and economics, and of fish preservation, processing, and transportati

[1] Kreuzer, R., ed. (1971) *Fish inspection and quality control*, London, Fishing Ne (Books) Ltd.

techniques ; they must also be aware of the rapid developments taking place in the industry. The inspectors must also be well trained and educated in fish and shellfish diseases and the adverse effects that many factors have on the wholesomeness and quality of fish and shellfish and their products.

13. RECOMMENDATIONS

Among the many matters discussed by the Committee the following recommendations should be given the highest priority. They are not listed in order of priority.

13.1 Recommendations related to programme development

(1) WHO and FAO should :

(*a*) develop their capability to advise countries on all matters related to fish and shellfish hygiene, including legislation, training and education, and organization of control services ;

(*b*) encourage the education and training of personnel at all levels in the governmental and industrial sectors in order to improve knowledge and practice of all aspects of fish and shellfish hygiene ; and

(*c*) advise national and international bodies to include fish and shellfish hygiene in courses of fishery technology.

(2) The establishment of microbiological standards for fish and shellfish and their products should be an essential part of the work now being undertaken to establish internationally acceptable microbiological standards for foods.

(3) Agencies responsible for the surveillance of fish and shellfish sanitation should maintain close liaison with agencies concerned with the environment so that the implications of manmade environmental changes on the quality of fish and shellfish can be evaluated, and where necessary appropriate action taken.

(4) The dissemination of information in relation to the identification of fish that might contain biotoxins should be improved.

13.2 Recommendations related to fish and shellfish research and technology

(1) Further investigations are required to determine the effect of processing and other factors on the inactivation of fish-borne parasites.

(2) Research is required to investigate the fundamental and practical principles and aspects of fish and shellfish handling techniques in warm climates. Special attention should be given to the study of the microbial flora of fish and the effects of the gutting and chilling processes.

(3) Research is required to investigate the ecology and epidemiology of *Vibrio parahaemolyticus* and *Clostridium botulinum* in relation to food species.

(4) High priority should be given to studies of virus diseases of importance to man that may be carried by fish and shellfish.

(5) The factors associated with the development of toxin in fish and shellfish taken as food should be studied, with particular emphasis on ciguatera and scombroid poisoning, and the development of a rapid laboratory test to determine the presence of toxin. The production of information material to help identify toxic species should be given high priority.

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TABLE 1. CHARACTERISTICS OF PRINCIPAL BACTERIAL

	Etiological Agent	Principal aquatic food animals involved as source of infection	Sources of infection for aquatic food animal	Pathogenicity for aquatic food animal
Bacterial infection	*Salmonella* spp. *a*) *S. typhi, S. paratyphi* *b*) other species (e.g., *S. typhimurium, S. enteritidis*)	fish or shellfish secondarily contaminated through polluted waters or through improper handling	*a*) human faeces and waters contaminated by human faeces *b*) human and animal faeces, polluted waters	nonpathogenic
	Vibrio parahaemolyticus	marine fish and shellfish	organism occurs naturally in the marine environment	may cause death of shrimps and crabs ; experimentally pathogenic for fish
Bacterial intoxication	*Clostridium botulinum*	fermented, salted, and smoked fish	sediment, water, animal faeces	toxin can kill fish
	Staphylococcus aureus	fish or shellfish secondarily contaminated through improper handling	man—nose and throat discharges, skin lesions	nonpathogenic
Bacterial intravital intoxication [2]	*Clostridium perfringens*	fish or shellfish secondarily contaminated through polluted waters or through improper handling	polluted waters, human and animal faeces, sediment	nonpathogenic
Bacterial skin infection	*Erysipelothrix insidiosa*	fish, particularly spiny ones (e.g., searobins, redfish) — organism is present in fish slime and meat		nonpathogenic
Viral infection	virus of infectious hepatitis	shellfish	human faeces and water polluted by human faeces	nonpathogenic

[1] The disease agent is widely distributed throughout many areas of the world, but fish- or shellfish-borne disease appears to occur only sporadically.

) VIRAL FISH- AND SHELLFISH-BORNE DISEASES OF MAN

e of transmission an	Disease in man and most common manifestations	Control	Geographical distribution
stion of raw or fficiently cooked aminated fish or fish	*a)* typhoid and paratyphoid fever, septicaemia *b)* salmonellosis : gastroenteritis	— proper sewage disposal — hygienic handling — adequate cooling — adequate cooking — restriction of fishing or harvesting in polluted waters — relaying and purification of shellfish from polluted waters	widely distributed [1]
lly through conption of raw or equately cooked or shellfish that not been properly gerated	diarrhoea, abdominal pain	— hygienic handling — correct processing — adequate cooling	reported primarily from Japan because of food habits (eating raw fish) ; recently reported from USA and England
stion of improperly essed fish or fish	botulism : neurological symptoms with high case-fatality rate	— correct processing — cooking just prior to eating food	widely distributed [1]
stion of fish or fish cross-aminated after ing	staphylococcal intoxication : nausea, vomiting, abdominal pain, prostration	— hygienic handling — adequate cooling	widely distributed [1]
stion of cooked or shellfish that not been properly gerated	diarrhoea, abdominal pain	— rapid cooling of food after cooking	widely distributed [1]
gh skin lesions—ly an occupational se	erysipeloid—severe inflammation of superficial cutaneous wounds	— care in handling fish	
tion of raw or quately cooked minated shellfish	infectious hepatitis	— proper sewage disposal — adequate cooking — restriction of harvesting in polluted waters — relaying and purification of shellfish from polluted waters	widely distributed [1]

[2] Intoxication by toxin produced in the body by bacteria present in heavily contaminated foods.

TABLE 2. CHARACTERISTICS OF PRINCIPAL PARASITIC

	Etiological agent	Principal aquatic food animals involved as source of infection	Life cycle of parasite	Pathogenicity for aquatic food animal
Parasitic infection — trematodes	*Clonorchis sinensis* (Chinese liver fluke)	freshwater fish—Cyprinidae family (e.g., carp, roach, dace)	1st intermediate host : snail 2nd intermediate host : fish Definitive host : man, dog, cat, other fish-eating mammals	muscle cyst infection
	Opisthorchis felineus *O. viverrini*	freshwater fish—Cyprinidae family (e.g., whitefish, carp, tench, bream, barbel)	1st int. host : snail 2nd int. host : fish Def. host : man, dog, fox, cat, other fish-eating mammals	muscle and subcutaneous cyst infection
	Heterophyes heterophyes	freshwater or brackish-water fish	1st int. host : snail 2nd int. host : fish Def. host : man, dog, cat, other fish-eating mammals, fish-eating birds	encyst in muscles and skin
	Metagonimus yokogawai	freshwater fish (e.g., trout, sweet-fish, dace, white-bait)	1st int. host : snail 2nd int. host : fish Def. host : man, dog, pig, cat, fish-eating birds	encyst in gills fin or tail
	Paragonismus westermani *P. ringeri* (Oriental lung fluke)	freshwater crab and crayfish	1st int. host : snail 2nd int. host : crab, crayfish Def. host : man, dog, pig, wild carnivores	encyst in gills muscle, heart liver
— cestodes	*Diphyllobothrium latum*	freshwater fish (e.g., pike, trout, turbot)	1st int. host : copepod 2nd int. host : fish Def. host : man, dog, cat, pig, fox, polar bear, other fish-eating mammals	plerocercoid larvae infecti of muscles a other organs
— nematodes	*Anisakis matina*	marine fish (e.g., cod, herring, mackerel)		internal larva infection
	Angiostrongylus cantonensis	freshwater shrimp, land crab, possibly certain marine fish	1st int. host : slug, land snail Def. host : rat Paratenic hosts : shrimp, land crab	

de of transmission man	Disease in man and most common manifestations	Control	Geographical distribution
stion of raw or fficiently cooked, cted fish (dried, ed or pickled fish be involved)	clonorchiasis : signs and symptoms related to liver damage	— proper sewage disposal — snail control — adequate cooking — adequate freezing — adequate salting	eastern Asia— esp., Japan, Korea, China, Viet-Nam
estion of raw or ufficiently cooked, cted fish	opisthorchiasis : cirrhosis of the liver		*O. felineus*— southern Asia, Europe, Canada *O. viverrini*— Thailand, Laos
estion of raw or ufficiently cooked, cted fish (fre- ntly salted or d fish)	heterophyiasis : abdominal pain, mucous diarrhoea ; eggs may be carried to the brain, heart, etc., causing atypical signs	— proper sewage disposal — snail control — adequate cooking — adequate freezing	eastern Asia, eastern Mediterranean area, particularly Egypt
estion of raw or ufficiently cooked, cted fish	metagonimiasis : usually mild diarrhoea		eastern Asia, Balkans, Egypt
stion of raw or fficiently cooked, cted crabs or cray- , or ingestion of r contaminated by acercariae that escaped from a or crayfish	paragonimiasis : usually chronic cough and haemoptysis from flukes localized in the lungs ; flukes may invade other organs	— proper sewage disposal — snail control — adequate cooking of crustaceans	*P. westermani*— eastern Asia, parts of Africa, S. America, Pacific Islands *P. ringeri*— China
stion of raw or fficiently cooked, (frequently inade- ely pickled fish)	diphyllobothriasis : disease may be mild or inapparent ; may see signs of gastro-enteritis, anaemia, weakness	— proper sewage disposal — inspection of fish — adequate cooking — adequate freezing	patchy distribution mainly in the temperate zones
lly from ingestion w or partially- ed, pickled or ked herring	anisakiiasis : eosinophilic enteritis	— gutting of fish soon after catch — adequate cooking — adequate freezing — adequate salting	Netherlands, Japan, England
stion of raw or equately cooked np or crabs etimes pickled)	eosinophilic meningitis	— snail control — adequate cooking	Pacific Islands, South-East Asia

Annex 2

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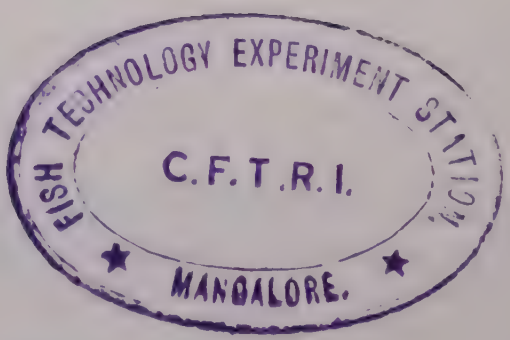

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